









Unit 2 - Organic Chemistry

Organic compounds: compounds that contain carbon, except $\text{CO}_{(g)}$, $\text{CO}_{2(g)}$, and ionic compounds with carbon.

Hydrocarbons: organic compounds that contain only carbon and hydrogen atoms in their molecular structure.

Straight Chain Alkanes

Alkanes: a hydrocarbon with only single bonds between carbon atoms

IUPAC Name	Molecular formula	Structural formula	Line formula
Methane	CH_4	$\begin{array}{c} \text{H} \\ \\ \text{H}-\text{C}-\text{H} \\ \\ \text{H} \end{array}$	N/A
Ethane	C_2H_6	$\begin{array}{cc} \text{H} & \text{H} \\ & \\ \text{H}-\text{C} & -\text{C}-\text{H} \\ & \\ \text{H} & \text{H} \end{array}$	N/A
Propane	C_3H_8	$\begin{array}{ccc} \text{H} & \text{H} & \text{H} \\ & & \\ \text{H}-\text{C} & -\text{C} & -\text{C}-\text{H} \\ & & \\ \text{H} & \text{H} & \text{H} \end{array}$	
Butane	C_4H_{10}	$\begin{array}{cccc} \text{H} & \text{H} & \text{H} & \text{H} \\ & & & \\ \text{H}-\text{C} & -\text{C} & -\text{C} & -\text{C}-\text{H} \\ & & & \\ \text{H} & \text{H} & \text{H} & \text{H} \end{array}$	
Pentane	C_5H_{12}	$\begin{array}{ccccc} \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \\ & & & & \\ \text{H}-\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C}-\text{H} \\ & & & & \\ \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \end{array}$	
Hexane	C_6H_{14}	$\begin{array}{cccccc} \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \\ & & & & & \\ \text{H}-\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C}-\text{H} \\ & & & & & \\ \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \end{array}$	
Heptane	C_7H_{16}	$\begin{array}{ccccccc} \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \\ & & & & & & \\ \text{H}-\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C}-\text{H} \\ & & & & & & \\ \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \end{array}$	
Octane	C_8H_{18}	$\begin{array}{cccccccc} \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \\ & & & & & & & \\ \text{H}-\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C}-\text{H} \\ & & & & & & & \\ \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \end{array}$	
Nonane	C_9H_{20}	$\begin{array}{ccccccccc} \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \\ & & & & & & & & \\ \text{H}-\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C}-\text{H} \\ & & & & & & & & \\ \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \end{array}$	
Decane	$\text{C}_{10}\text{H}_{22}$	$\begin{array}{cccccccccc} \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \\ & & & & & & & & & \\ \text{H}-\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C} & -\text{C}-\text{H} \\ & & & & & & & & & \\ \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} & \text{H} \end{array}$	
-ane	$\text{C}_n\text{H}_{(2n+2)}$		

Branch-Chain Alkanes

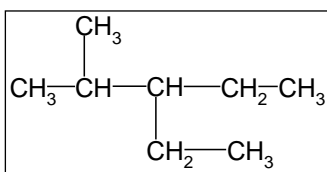
Alkyl group: a hydrocarbon group derived from an alkane by the removal of a hydrogen atom.

Some examples of alkyl groups include $-\text{CH}_3$ (methyl), $-\text{C}_2\text{H}_5$ (ethyl), $-\text{C}_3\text{H}_7$ (propyl), etc.

Nomenclature steps:

- 1) Find the longest carbon chain. This will be the parent chain.
- 2) Start numbering the carbons on the parent chain starting at the carbon closest to the first branch.
- 3) Write branches in alpha order, not numerically.

Ex. 1



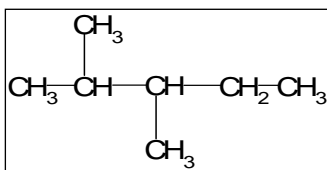
The longest carbon chain is 5 carbons long. The parent chain is pentane

There are two branches. A methyl group and a ethyl group.

Therefore, this hydrocarbon is **3-ethyl-2-methylpentane**

If there are more than one of the same type of alkyl group, use the *di*, *tri*, etc. prefixes.

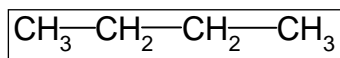
Ex. 2



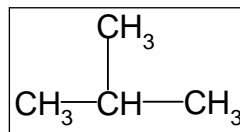
2,3-dimethylpentane

Structural Isomers: chemicals with the same molecular formulas but have different structural formulas and different names.

Ex 3 - C_4H_{10}



butane



isobutane or 2-methylpropane

Properties of alkanes

- Non-polar, therefore have LDF attractive forces
- Low molecular masses, low melting points, low boiling points
- State of matter
 - 1-4 C \rightarrow gas
 - 5-17 C \rightarrow liquid
 - 18+ C \rightarrow solids

Insoluble in water but will dissolve non-polar solvents (like dissolves like)

From textbook: Read pg 15-21 Do pg 19 # 1-11; pg 21 #12-14, 16-21

Alkenes & Alkynes

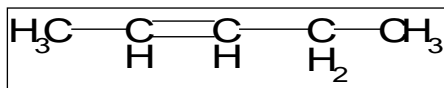
Alkenes: a hydrocarbon with one or more double bonds between carbon atoms

Alkynes: a hydrocarbon with one or more triple bonds between carbon atoms

Nomenclature steps:

- 1) Find the longest carbon chain. This will be the parent chain.
- 2) If the carbon chain contains a double bond, use the suffix **-ene**
If the carbon chain contains a triple bond, use the suffix **-yne**
- 3) Start numbering the carbons on the parent chain starting at the carbon closest to the largest multiple bond.
- 4) Write branches in alpha order, not numerically.

Ex. 1

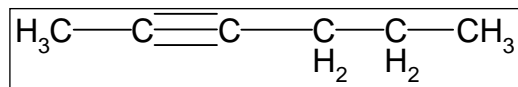


The longest carbon chain is 5 carbons long. The parent chain is pentane

There is a double bond starting at the 2nd carbon

Therefore, this hydrocarbon is **2-pentene**

Ex. 2



The longest carbon chain is 6 carbons long. The parent chain is hexane

There is a triple bond starting at the 2nd carbon

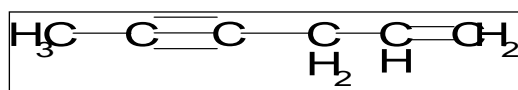
Therefore, this hydrocarbon is **2-hexyne**

If there is only one multiple bond and it is on the first carbon, there is no need to prefix the name with the number 1.

ie. 1-pentene can simply be called pentene.

If there is more than one multiple bond, use the *di*, *tri*, etc. prefixes as before.

Ex. 3



The longest carbon chain is 6 carbons long. The parent chain is hexane

There is a double bond on the 1st carbon and a triple bond starting at the 4th carbon

Therefore, this hydrocarbon is **1-hexene-4-yne**

Ex. 4



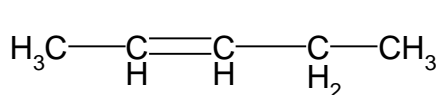
The longest carbon chain is 7 carbons long. The parent chain is heptane

There are double bonds on the 2nd and 4th carbons

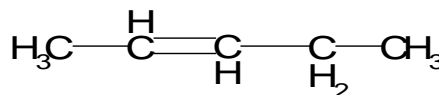
Therefore, this hydrocarbon is **2,4-heptadiene**

Cis / Trans

Looking at 2-pentene, the hydrogens located on the 2nd and 3rd carbons are on the same side, however it is possible for them to be on opposite sides, as well. These are two different isomers of 2-pentene. Therefore, we must distinguish between them. When hydrogens are on the same side of the double (or triple) bond, we use the suffix **cis**, if they are on opposite sides we use **trans**.



cis-2-pentene



trans-2-pentene

From textbook: Read pg 8-13; pg 22-30 Do pg 14 #4, 5, 10; pg 26 #23-34; pg45-54

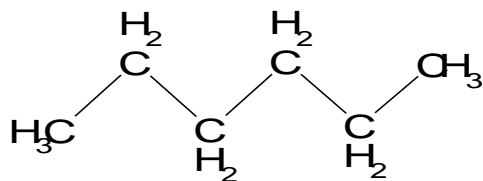
Cycloalkanes

Acyclic hydrocarbons: open-chain hydrocarbons without any rings of carbon atoms.

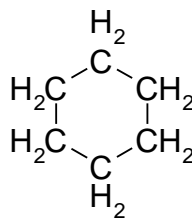
Alicyclic hydrocarbons: hydrocarbons with a carbon-carbon bond structure forming a closed ring. Sometimes just called cyclic hydrocarbons

Nomenclature

A cyclic compound has the prefix **cyclo-** to indicate the ring structure.

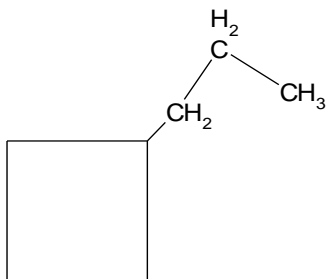


hexane



cyclohexane

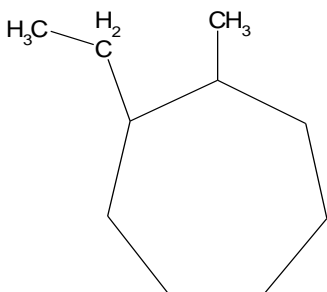




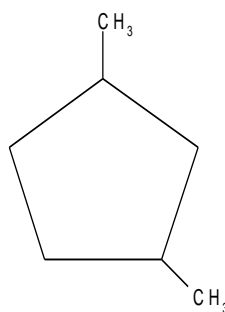
propylcyclobutane

When cyclic hydrocarbons have multiple substituent groups, or branches, they are listed in alphabetical order, and the first substituent is assigned to carbon #.

Ex. 1



1-ethyl-2-methylcycloheptane

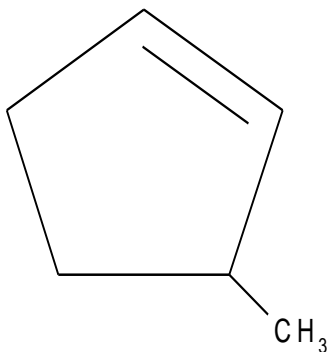


1,3-dimethylcyclopentane

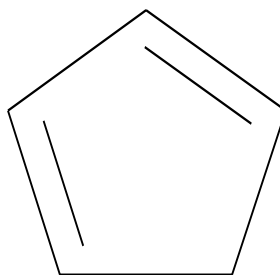
Cycloalkenes & Cycloalkynes

Nomenclature for cyclic alkenes and alkynes is the same as cycloalkanes, except that numbering starts at the multiple bond.

Ex. 2



3-methylcyclopentene

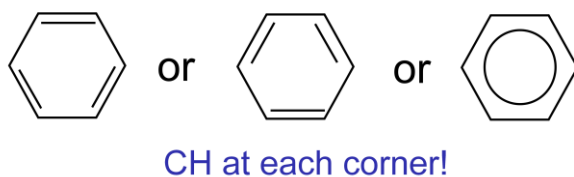


1,3-cyclopentadiene

Aromatic Compounds

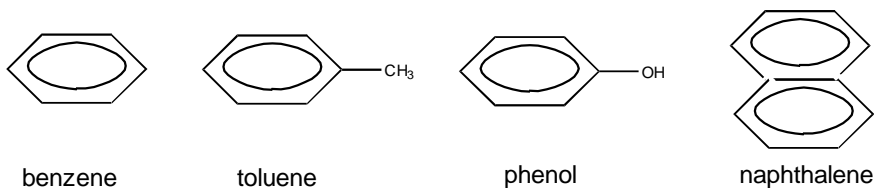
Originally meant odourous, but the definition has been altered to mean a compound that contains a benzene ring.

1,3,5-cyclohexatriene (aka Benzene):

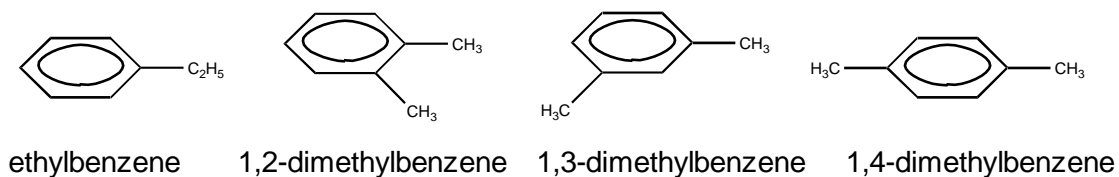


Nomenclature

Named using benzene or derivatives of benzene (toluene or phenol) as root name

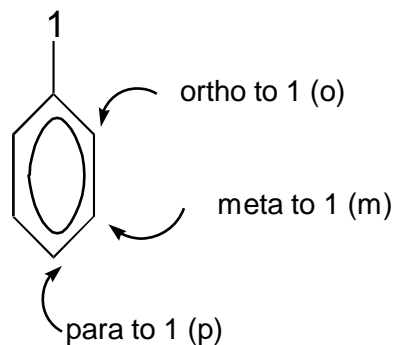


Examples:

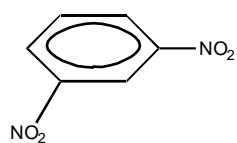


Ortho, Meta, & Para

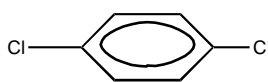
Prefixes used to designate three possible arrangements of disubstituted benzene



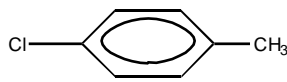
Examples:



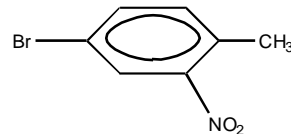
m-dinitrobenzene



p-dichlorobenzene

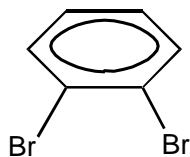


p-chlorotoluene



4-bromo-2-nitrotoluene

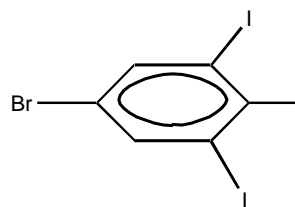
1)



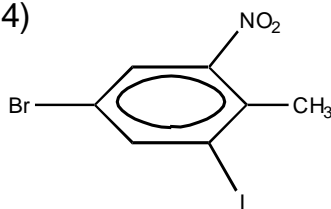
2)



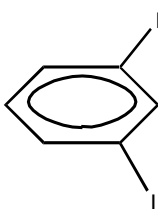
3)



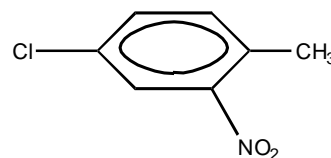
4)



5)



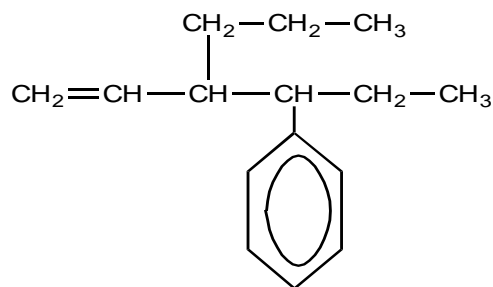
6)



The Phenyl Group

A benzene ring can also be the attached branch. This is called a *phenyl* group. (C_6H_5)

Example: 4-phenyl-3-propyl-1-hexene



Properties of aromatics

- Many derived from petroleum
- Act as good solvents for organic compounds
- Tend to be toxic. Always use a fumehood when handling aromatic compounds

From textbook: Read pg 30-39 Do pg 34 # 55-64; pg 38 #65-74

Fractional Distillation

Distillation is a process used to separate the various hydrocarbons in a mixture from one another by using the differences in boiling points.

For example, crude oil is a mixture of various hydrocarbons. These hydrocarbons can range from relatively short chains up to long chains (over 40 carbons long).

# Carbon Atoms	Boiling Point	Primary use
1 – 5	Under 30° C	Fuels for heat and cooking
5 – 6	30° C to 90° C	Camp fuel/dry-cleaning solvents
5 – 12	30° C to 200° C	Gasoline
12 – 16	175° C to 275° C	Kerosene and diesel fuels
15 – 18	250° C to 375° C	Furnace oil
16 – 22	Over 400° C	Heavy greases for lubrication
Over 20	Over 450° C	Waxes, cosmetics and polishes
Over 26	Over 500° C	Asphalt and tar for roofs and roads

To separate high demand (and cost) from the low demand products, the oil subjected to a distillation process. Notice the boiling points - as a general rule, the lower the number of carbon atoms, the lower the boiling point.

Steps to Fractional Distillation:

- 1) The mixture is heated at a high temperature. This will ensure that all hydrocarbons evaporate.
- 2) The temperature is then slowly lowered
- 3) The gases will condense at different temperatures (their particular boiling points)
- 4) As the hydrocarbon gases condense back to a liquid, they are collected

Why does this occur?

Hydrocarbons are **non-polar** molecules, which means they are held together by weak **London Dispersion Forces**. As a hydrocarbon chain increases in size, more energy is required to separate the molecules from each other, thus the boiling point increases.

Cracking

High value hydrocarbons are gasoline and its immediate by-products. These are typically branched chains with 5 to 12 carbon atoms. As discussed above, crude petroleum is mixture of many hydrocarbons; most straight hydrocarbon chains some as long as 40. Cracking is a process of converting these long straight chains into the more profitable shorter branched chains.

Functional Groups

A functional group is a combination of atoms that determine the physical and chemical characteristics of a compound.

Carbon-Carbon double or triple bonds

- Double and triple bonds are easier to break than single bonds
- Hence compounds containing these are more reactive than those with single bonds

Halogens

- Unequal sharing of electrons result in polar bonds
- This increases intermolecular attraction, increasing the boiling point and melting point

Chemical Reactions

As we see larger, more complicated molecules, a short-hand is useful:

Group	Short-Hand
Alkyl group	R, R', R'', etc.
Halogen atom	X
Phenyl group	Ø

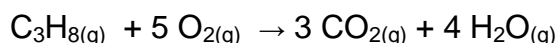
For instance

R- Ø represents an alkyl group attached to a benzene ring.

Complete Combustion:

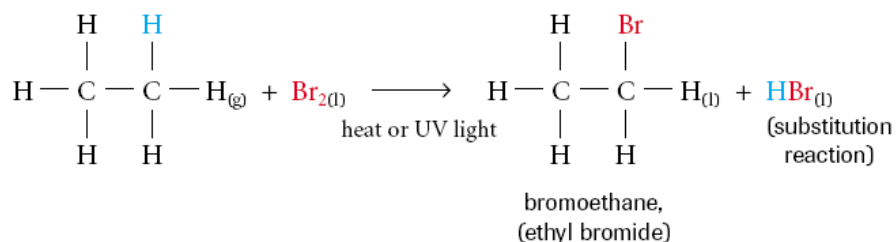
hydrocarbon + oxygen => carbon dioxide + water

by-products are light and heat; hydrocarbons are very useful as fuels

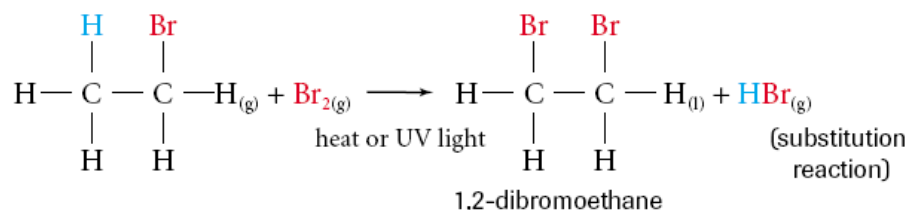


Substitution Reactions:

One (or more) H atoms are substituted by a halogen (F_2 , Cl_2 , Br_2)



If allowed to continue, more Br may be added.

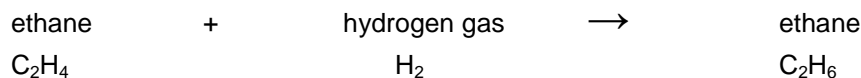


Synthesis/Addition Reactions of Alkenes and Alkynes:

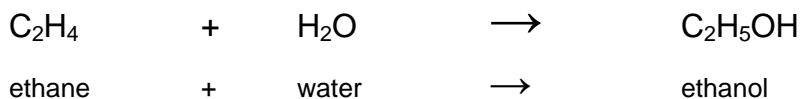
A saturated hydrocarbon contains only single bonds

An unsaturated hydrocarbon contains at least one double or triple bonds

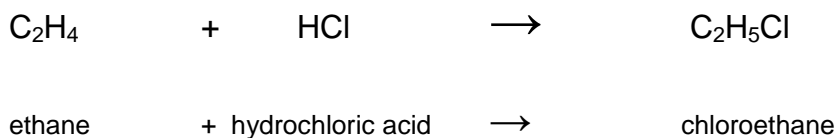
Unsaturated hydrocarbons (alkenes and alkynes), because of the multiple bonds, are more reactive than alkanes. The double and triple bonds are targets for addition reactions, which cause molecule to go from an unsaturated state to a saturated state.



Similarly,



and



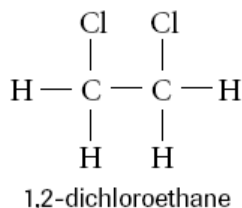
Markovnikov's Rule – When a hydrogen halide or water is added to an alkene or alkyne, the hydrogen atom bonds to the carbon atom within the double bond that *already has more hydrogen atoms*. This rule may be remembered simply as “the rich get richer”.



Organic Halides

- Halides are organic compounds that contain the presence of halogen
- General form of a halide is R-X
- To name halides, give the location of the -X and add the appropriate prefix:

-F	Fluoro	-Br	Bromo
-Cl	Chloro	-I	Iodo



Properties of Organic Halides

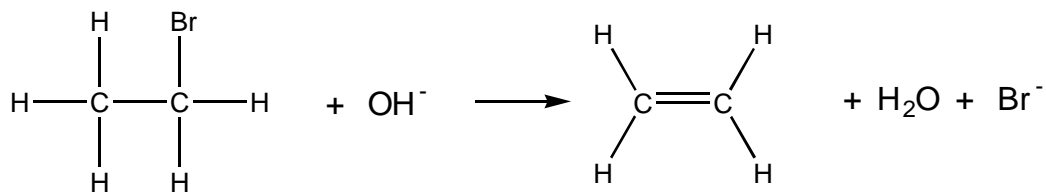
- o Polar halogen group increases polarity of molecule
- o Hence boiling points and melting points are increased compared to their respective alkanes
- o Because “like dissolves like”, increased polarity makes them more suitable in polar solvents

Preparing Organic Halides

- o Substitution reactions with an alkane
- o Halogenation or hydrohalogenation of alkene/alkyne
- o Halogenation of an aromatic

Reactivity of organic halides

- o Elimination reactions to form an alkene
- o hydrogen and halide removed from adjacent carbons
- o Common way of preparing alkenes
- o Requires hydroxide ions



Alcohols

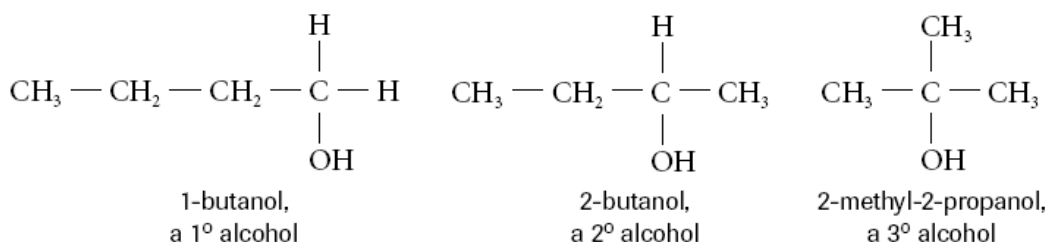
- Alcohols are organic compounds that contain the presence of hydroxyl functional group -OH
- General form alcohol is R-OH (R implies a general alkane chain)
- Examples:
 - o Methanol CH_3OH (from methane CH_4) = very toxic compound
 - o Ethanol $\text{CH}_3\text{CH}_2\text{OH}$ (beer and wines)
 - o 2-Propanol $\text{CH}_3\text{CH}(\text{OH})\text{CH}_3$ (rubbing alcohol)
- To name alcohols, give the location of the -OH and add the suffix "ANOL"

2-hexanol

3-heptanol

Types of alcohols – 1° , 2° , 3°

- o depends on location of the -OH functional group
- o primary alcohol: the -OH group is bonded to a carbon that is bonded to only **one** other carbon atom
- o secondary alcohol: the -OH group is bonded to a carbon that is bonded to **two** other carbon atoms
- o tertiary alcohol: the -OH group is bonded to a carbon that is bonded to **three** other carbon atoms.



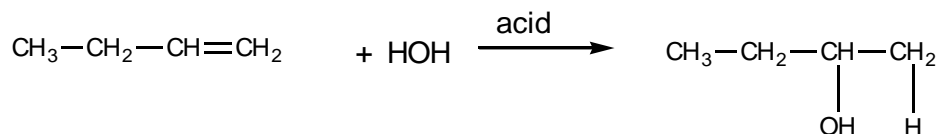
Properties of alcohol

- o Polar hydroxyl group allow hydrogen bonds to occur between molecules
- o Hence boiling points and melting points are increased compared to their respective alkanes
 Ethanol ($\text{CH}_3\text{CH}_2\text{OH}$) boils at 73°C
 Ethane (CH_3CH_3) boils at -89°C
- o Alcohols also have a higher solubility in water than alkanes; but the longer C chains on some alcohols also allow them to mix with nonpolar solvents as well
- o Alcohols also burn in the presence of O_2
 $\text{CH}_3\text{CH}_2\text{OH}(\text{g}) + 3\text{O}_{2(\text{g})} \rightarrow 3\text{H}_2\text{O} + 2\text{CO}_{2(\text{g})}$

Reactions involving alcohols

Hydration reactions

- follow Markovnikov's rule
- requires alkene, water and sulfuric acid as a catalyst



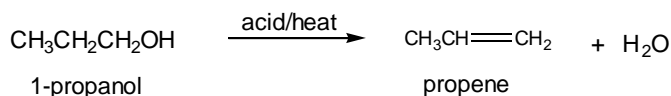
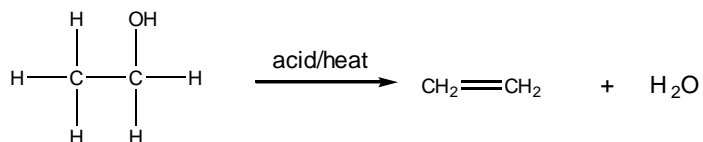
Fermentation of sugars

- yeast (fungus) breaks down sugars, in the absence of oxygen, to produce carbon dioxide and ethanol



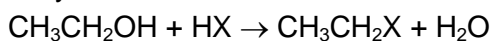
Dehydration reactions (elimination reaction)

- Conditions: high temperatures and acid catalyst
- Description: H_2O is eliminated and a double bond is formed



Hydrohalogenation reactions

- reacts with HX to produce alkyl halide and water



Ethers

- organic compounds that have an oxygen attached to TWO hydrocarbon alkyl chains
- general form is R-O-R'
- To name ethers:
prefix of shorter hydrocarbon chain attached to oxygen + OXY + alkane name of the longer chain
OR
State the two alkyl groups, followed by the term "ether"
- Examples:

ethoxyethane

or

diethyl ether

ethoxyhexane

or

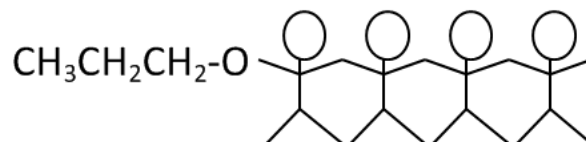
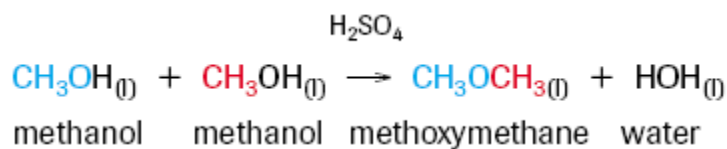
ethyl hexyl ether

Properties of ethers

- o More polar than alkane types of hydrocarbons. Hence boiling points and melting points are increased compared to their respective alkanes
- o boiling points and melting points are higher than respective alkanes but lower than alcohols
- o ethers do mix well with both polar and nonpolar substances, making them good solvents

Preparing Ethers

- o *Condensation reaction:* Two alcohols will react to form water and an ether in the presence of sulfuric acid

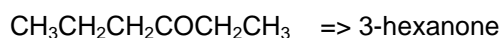


propyl people ether

Ketones

Both aldehydes and ketones contain **carbonyl functional group** – oxygen with a double bond to carbon **C=O**

- The carbonyl group is found in the interior of the carbon chain
- The general form is
- To name ketones:
Location of carbonyl group + alkane name + “anone” suffix
- Examples:



Aldehydes

- The carbonyl group is located at the end of the carbon chain
- The general form is

- To name aldehydes:
alkane name + “anal” suffix

NOTE – no number is necessary as by definition, the carbonyl group is at an end C

- Examples:

methanal (formaldehyde)

pentanal

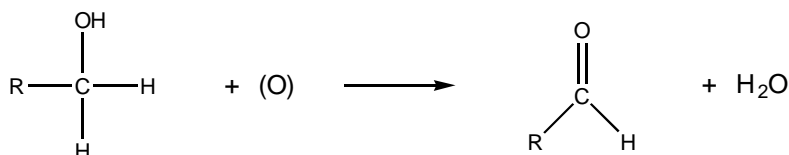
Properties of ketones & aldehydes

- o ketones and aldehydes have lower boiling points and melting points than alcohols but still higher than alkanes
- o less soluble in water than alcohols because they do NOT contain the –OH
- o good solvents because they mix relatively well with both polar and nonpolar compounds

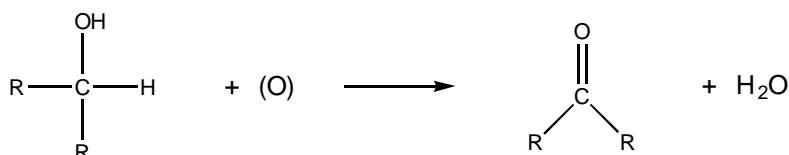
Preparing ketones & aldehydes

- **Oxidation Reactions:** reaction in which a carbon atom forms more bonds to oxygen or less bonds to hydrogen
- oxidizing agent removes **two** H atoms, one from the –OH group, and one from the **C** to which the –OH group is attached to form a C=O group and a water molecule
- Conditions: requires an oxidizing agent (H_2O_2 , $\text{K}_2\text{Cr}_2\text{O}_7$, KMnO_4). The oxidizing agent supplies the reactive oxygen atom which is symbolized by (O).

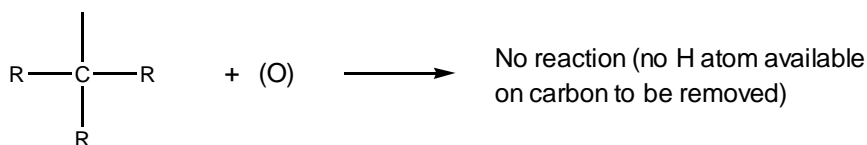
primary



secondary

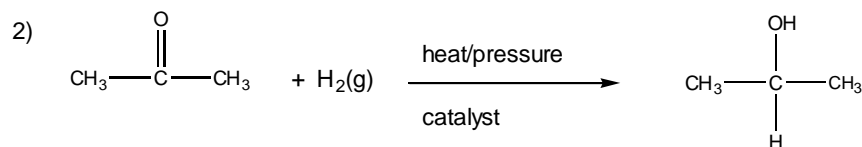
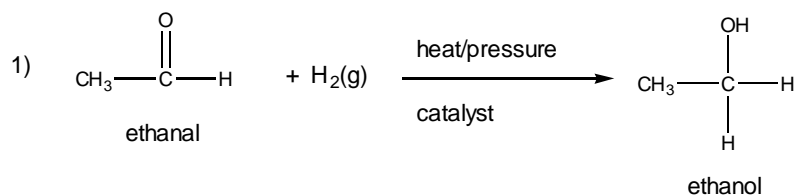


tertiary



Reactions of ketones & aldehydes

- **Hydrogenation:** aldehydes and ketones react with $\text{H}_{2(g)}$ under heat, pressure, and the presence of a catalyst to form alcohols
- reverse of oxidation reaction
- aldehydes produce primary alcohols
- ketones produce secondary alcohols



Carboxylic Acids

- Organic compounds that contain a **carboxyl functional group** – an end carbon with both a carbonyl and hydroxyl group.
- The general form is

- To name aldehydes:
alkane name + “anoic acid” suffix

NOTE – As with aldehydes, no number is necessary as by definition, the carboxyl group is at an end C

- Examples:



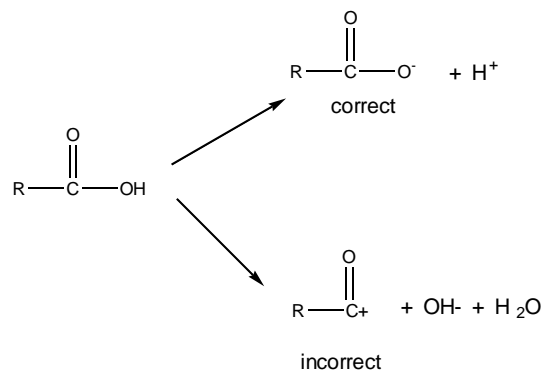
butanoic acid

Properties of carboxylic acids

- o have some of the same properties of all other acids:
 - turns litmus paper red
 - neutralize bases
- o polar molecules; capable of forming hydrogen bonds
- o solubility is dependent on the length of the hydrocarbon chain of the acid \Rightarrow smaller chains (first four) are more soluble than longer chains
- o high boiling points and melting points due to H-bonding

Explaining acidic properties of carboxylic acids

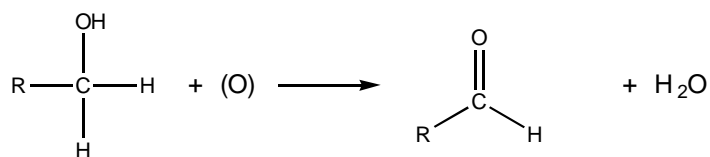
- o the –OH group in a carboxylic acid does not behave like the basic hydroxide ion, OH^- . Oxygen has a high electronegativity and there are 2 oxygen atoms present to help carry the extra negative charge that is caused when a positive hydrogen atom dissociates.



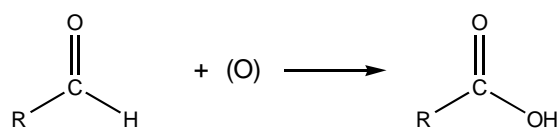
Properties of carboxylic acids

- Primary alcohol is oxidized to an aldehyde. The aldehyde can be oxidized further to become a carboxylic acid.

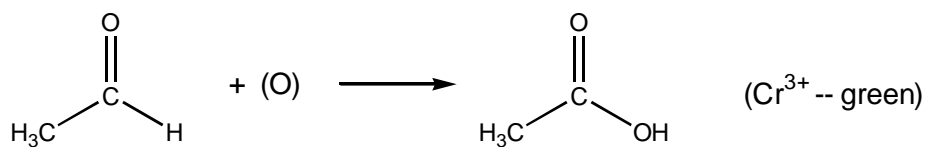
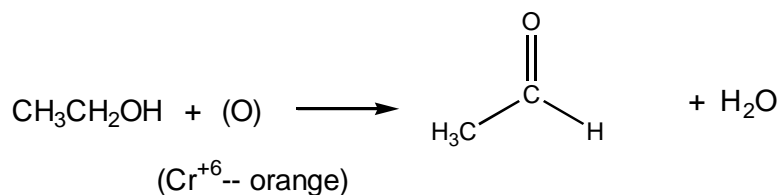
Step 1



Step 2

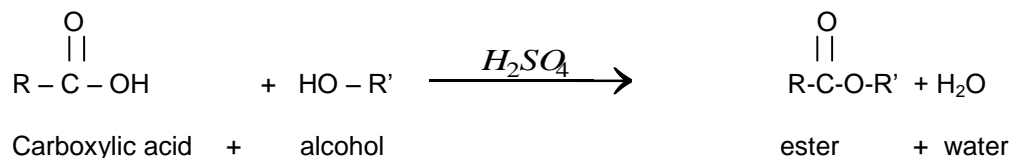


This type of reaction is used in the breathalyzer test for alcohol. The oxidizing agent used is the chromate ion ($\text{Cr}_2\text{O}_7^{2-}$). It changes from Cr^{+6} to Cr^{3+} in the reaction process. The two ions have different colours (orange to green).



Esters

- Esters are responsible for many of the artificial smells and tastes in products – cherry coke for example. (See Table 2 on p 64 for some common examples)
- Created by a process called **esterification** – example of a condensation reaction in which larger molecule is produced from two smaller ones, with release of water
- Esters are formed by reacting a carboxylic acid and an alcohol



- General form is $\begin{array}{c} \text{O} \\ || \\ \text{R} - \text{C} - \text{O} - \text{R}' \end{array}$
- To name esters:
first part of name is alkyl group attached to –O-; second part is prefix of hydrocarbon attached to carboxyl + “ANOATE”
- Examples:

Ethyl butanoate

Methyl propanoate

Reactions:

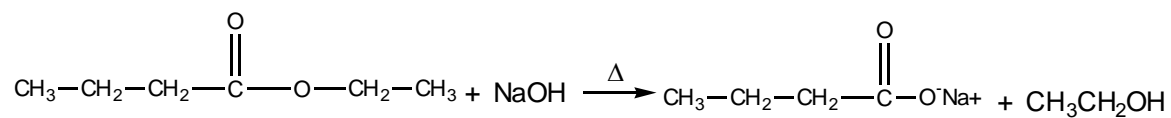
- can be split back into their components by process of hydrolysis
- esters are fats and oils of long chain carboxylic acids; in presence of strong bases (such as NaOH) and water hydrolysis occurs to create sodium salts (SOAP) and alcohol
 - o can be separated by distillation

Properties of esters:

- o esters do NOT contain –OH => not as capable of forming hydrogen bonds => lower intermolecular forces
- o lower boiling points and melting points than carboxylic acids
- o less soluble in water than carboxylic acids

Reactions of esters:

- the ester bond is cleaved (split in two) to form two products.
- produces the salt of a carboxylic acid and an alcohol.
- Carried out in a basic solution and usually requires heat
- Called **saponification** - soap is made by the basic hydrolysis of ester bonds in vegetable oils or animal fats



Amines

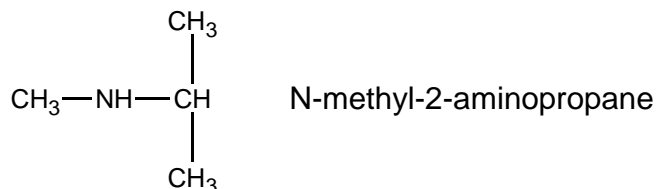
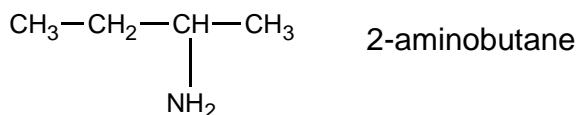
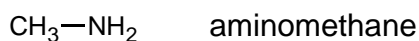
- Amine is an organic compound which contains a nitrogen attached to one or more alkyl groups
- There are three types of amines, and are named depending upon the carbon to which they are attached
 - An amine that has only one alkyl group attached to the nitrogen is called a **primary** (1°) amine
 - o General form is $R-NH_2$
 - An amine that has two alkyl groups attached to the nitrogen is called a **secondary** (2°) amine
 - o General form $R-NH-R'$
 - An amine that has three alkyl groups is called a **tertiary** (3°) amine
 - o General form $R-N(R')-R''$
- You can think of an amine as an ammonia molecule NH_3 in which one or more H has been replaced by an alkyl group.
- To name Primary amines:

(1°) Location of NH_2 on C-chain – “AMINO” + alkane name of the HC chain
OR

(1°) Location of NH_2 on C-chain - alkane name of the HC chain + “AMINE”

- To name Secondary & Tertiary amines:
Step 1: Identify the largest hydrocarbon group attached to the nitrogen atom as the parent alkane.
Step 2: Name the other alkyl group(s) attached to the nitrogen atom. Instead of position numbers, use the letter N- to locate the group(s). (If two identical alkyl groups are attached to the nitrogen atom, use N,N-). This is the prefix.
Step 3: Put the name together: prefix + alkyl + aminoalkane

- Examples:

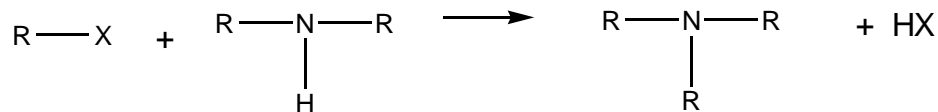
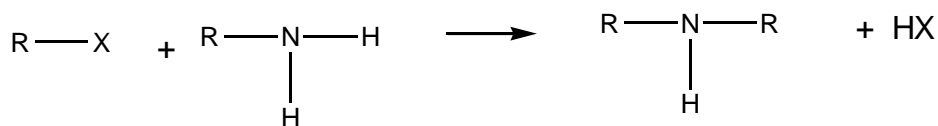
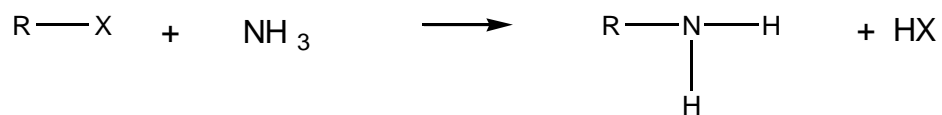


Properties of amines

- C-N and N-H bonds are polar. Thus, amines are usually polar.
- The presence of one or more N-H bonds allows hydrogen bonding to take place.
- Amines with low molecular masses (four or less carbon atoms) are completely miscible in water (hydrogen bonding).
- Boiling points of primary and secondary amines are higher than the boiling points of tertiary amines (absence of hydrogen bonding).
- Amines have lower boiling points than alcohols.
- Amines are found widely in nature.

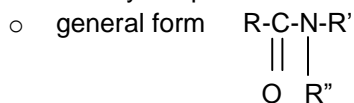
Preparing amines

- Reaction of ammonia with an alkyl halide to form an amine.
- Products are separated by fractional distillation due to the differences in boiling points.



Amides

- characterized by the presence of a carboxyl group (C=O) attached to the nitrogen



- To name amides:

Step 1: Locate the part of the amide that contains the C=O group. Name the parent carboxylic acid that this part derives from. **Note:** the carbon in the C=O group is always given position number 1.

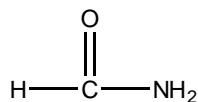
Step 2: Replace the “oic acid” ending of the name of the parent acid with the suffix “amide”

Step 3: Decide whether the compound is a primary, secondary, or tertiary amide.

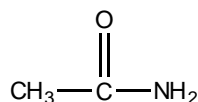
DESCRIPTION	TYPE	PREFIX
Only H atoms attached to the N atom	Primary amide	No prefixes required
One alkyl group attached to the N atom	Secondary amide	Name the alkyl group, and give it location N- to indicate that it is bonded to the N atom
Two alkyl groups attached to the N atom	Tertiary amide	Use location letter N- before each group to indicate that it is bonded to the N atom. If the two groups are identical, use N,N-

Step 4: Put the name together: prefix + root + suffix

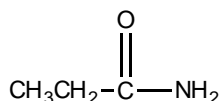
Examples:



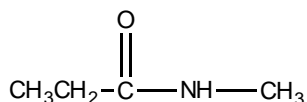
methanamide



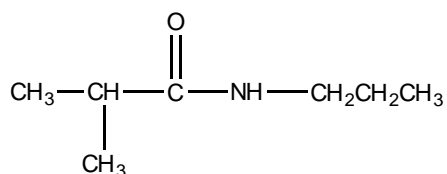
ethanamide



propanamide



N-methylpropanamide



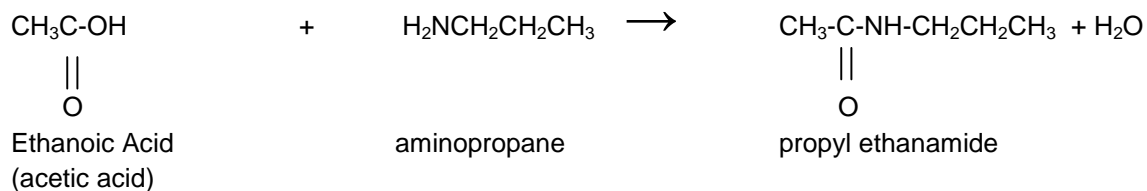
N-propyl-2-methylpropanamide

Properties of amides:

- C-N and N-H bonds are polar.
- Primary amides have two N-H bonds, therefore they have even stronger hydrogen bonds than carboxylic acids.
- Amides are soluble in water (solubility decreases as the non-polar hydrocarbon part of the molecule increases in size).
- Primary amides have much higher melting and boiling points than carboxylic acids.
- Acetaminophen (an amide) is a main component of many painkillers.
- Urea is another example of an amide. It was the first organic compound to be synthesized in a laboratory.

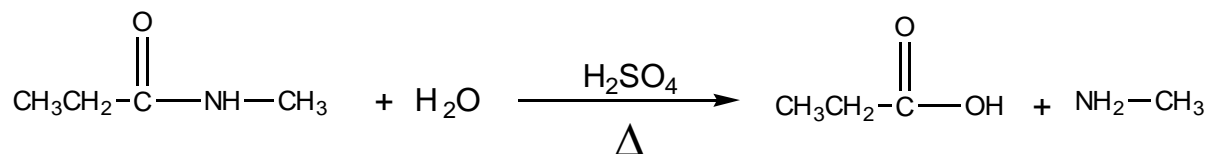
Preparing amides

- *Condensation Reactions*: reaction between a carboxylic acid and ammonia, or with 1°, or 2° amines (also organic bases) to produce an amide and water.



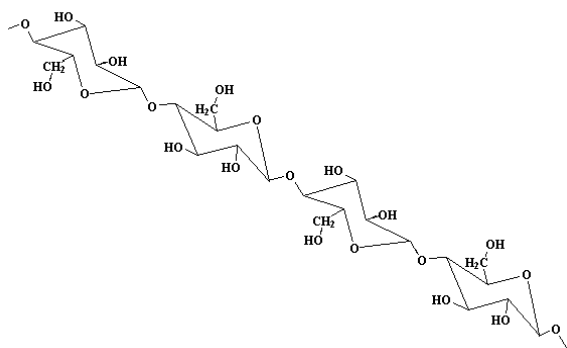
Reactions of amides:

- Amides undergo *hydrolysis* reactions (like esters)
- The hydrolysis of amides produces a carboxylic acid and an amine
- Basic (NaOH) or acidic (H₂SO₄) hydrolysis



Chapter 2 - Polymers

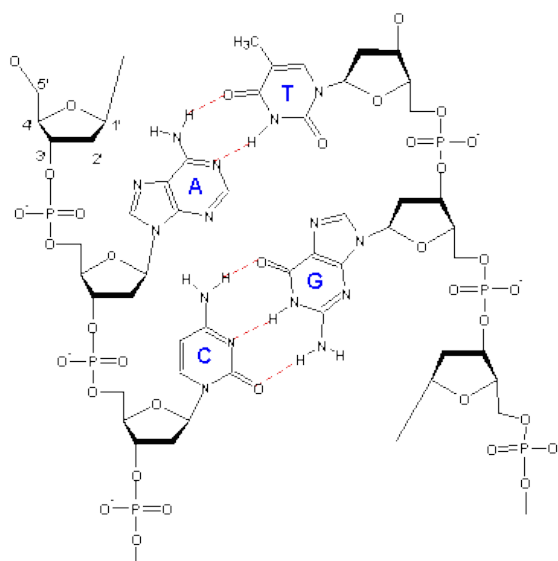
- an extremely large organic compound made of many repeating sub-units
- sub-units are called monomers
 - o not necessarily identical but do occur in a repeating pattern
 - $-A-A-A-A-A-$ $-A-B-B-A- A-B-B-A-$
 - $-A-B-A-B-A-$
- plastics are generally synthetic polymers
- depending on desired characteristics, polymers can be designed to have certain properties of strength, flexibility, durability, transparency or stability
- natural polymers include complex carbohydrates , proteins and DNA



Wood (glucose)



proteins (polymer of amino acid)



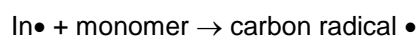
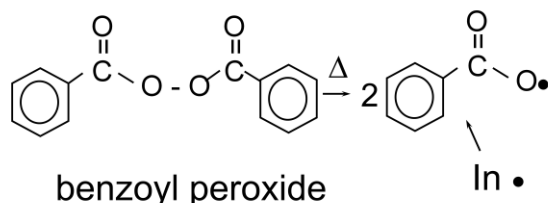
Nucleic acids

Addition Polymers

- polymers that form when monomer units are linked through addition reactions.
- Therefore, the monomers must contain double or triple bonds
- Three step process:

1) Initiation

- generate a radical initiator



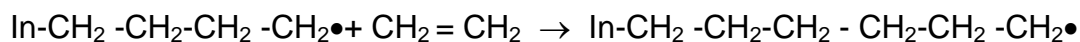
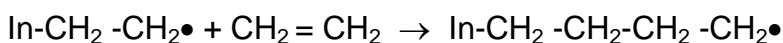
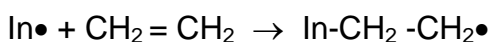
2) Propagation

- lengthens the chain
- the electrons shift in the newly bonded molecule, leaving one unpaired electron at the other end of its original double bond
- this unpaired electron forms another covalent bond with another atom or group.



3) Termination

- terminates the reaction when two unpaired electron ends combine forming a single covalent bond.

Eg Polymerization of an ethene (aka ethylene) monomer:



This makes polythene or polyethylene

Monomer	Polymer Name	Uses
$\text{H}_2\text{C}=\text{CH}_2$	Polyethylene	Garbage bags, wire insulation
$\text{H}_2\text{C}=\text{CHCH}_3$	Polypropylene	Rope, carpet fibre
$\text{H}_2\text{C}=\text{CHCl}$	Polyvinylchloride	Insulation pipe
$\text{H}_2\text{C}=\text{CH}$ 	Polystyrene	Styrofoam, molded items
$\text{H}_2\text{C}=\text{CHCN}$ 	Orlon, Acrilan	fibres
$\text{H}_2\text{C}=\text{CCO}_2\text{CH}_3$	Plexiglas, Lucite	molded items, paints

Monomer	Polymer Name	Uses
$\text{H}_2\text{C}=\text{CHOCOCH}_3$	polyvinylacetate	paints, adhesives
$\text{H}_2\text{C}=\text{CHOH}$	polyvinylalcohol	fibres, adhesives
$\text{F}_2\text{C}=\text{CF}_2$	Teflon	valves, gaskets, coatings

Properties of Plastics

- Plastics are polymers of substituted ethene (vinyl)
- Chemically unreactive due to carbon-carbon single bond
- Used for containers for chemicals, foods, etc
- Intermolecular forces: van der Waals and some electrostatic attractions for substituted groups
- Plastics are flexible and moldable due to weak intermolecular forces

Substituted Groups

Teflon

- $\text{CF}_2=\text{CF}_2$
- Strong C-F bonds account for unreactivity of teflon and its non-stick properties even at high temperatures

Plexiglass

- One H on ethene is replaced by $-\text{COOCH}_3$
- Group responsible for transparency and optical properties
- Presence of carbonyl group makes plexiglass soluble in other organic solvent containing a carbonyl group such as acetone

Crosslinking

- Occurs when monomers have two double bonds
- Dienes have two locations where addition can occur
- Dienes can attach to two separate chains at the same time (bridge)
- These bridges (crosslinks) hold the chains together making the polymer much stronger
- Amount of diene added dictate the rigidity of the polymer
- An example of a crosslinking agent is (1,4-diethenylbenzene)



Synthetic Condensation Polymers

- A reaction in which monomers are joined together by the formation of ester or amide bonds
- A water molecule is also produced
- Each monomer must have two functional groups (one at each end)
- Used for fabrics and fibres

Two “difunctional” molecules → a single molecule

That single molecule + another single molecule → a bigger single molecule

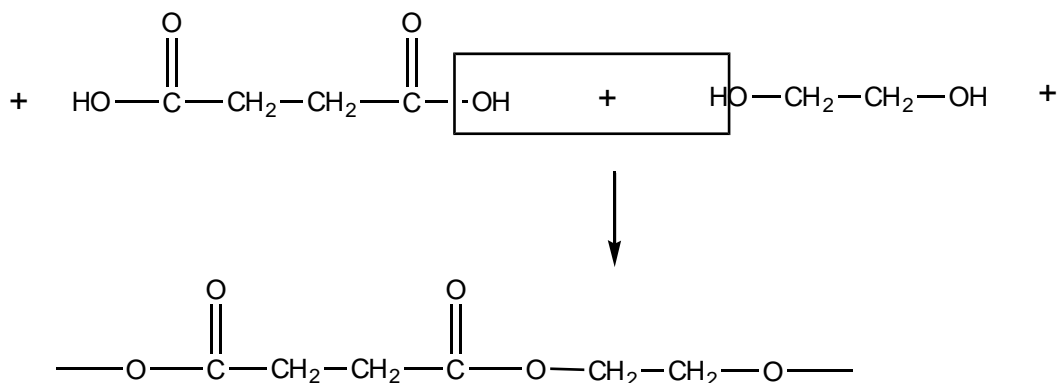
Etc.

Examples of Condensation Polymers:

Name	Structure	Uses
Dacron™ (a polyester)		<ul style="list-style-type: none"> •synthetic fibres used to make fabric for clothing and surgery
Nylon-6 (a polyamide)		<ul style="list-style-type: none"> •tires •synthetic fibres used to make rope and articles of clothing, such as stockings

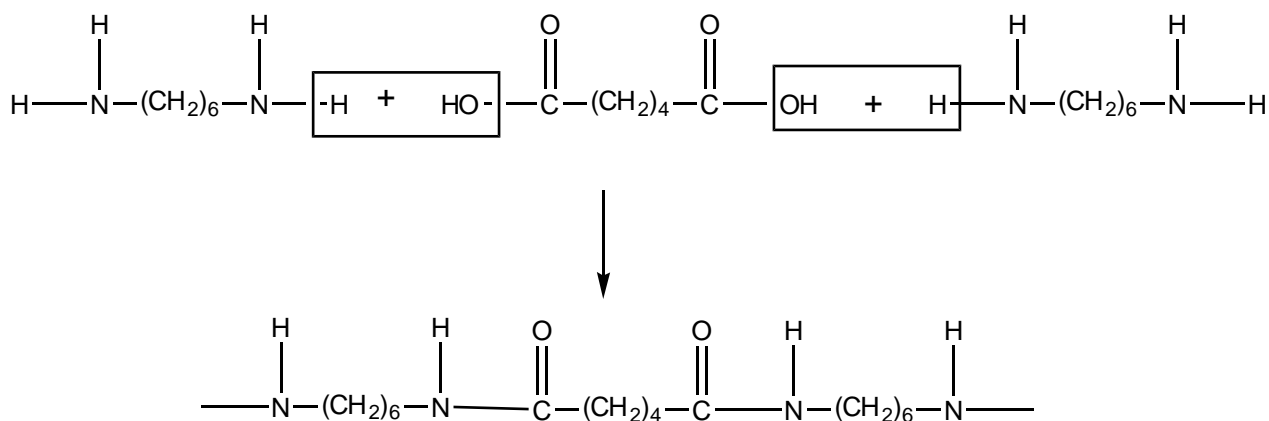
Polyesters

- Condensation polymers that contain ester bonds
- Results from the esterification of dicarboxylic acids and dialcohols or monomers containing both a carboxyl and a hydroxyl group
- Ester linkages are formed end to end between alternating acid molecules and alcohol molecules



Polyamides (aka Nylons)

- Condensation reaction between a carboxylic acid and an amine, with the removal of water to form an amide bond
- Monomers must be dicarboxylic acids and diamines or monomers containing both a carboxyl and an amine group
- Nylon-66 is a polyamide, Kevlar is a polyamide with crosslinking.



Natural Polyamides - Proteins